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Simulation Environment for Onboard Fire Network Model Version 1.0 — User's Manual

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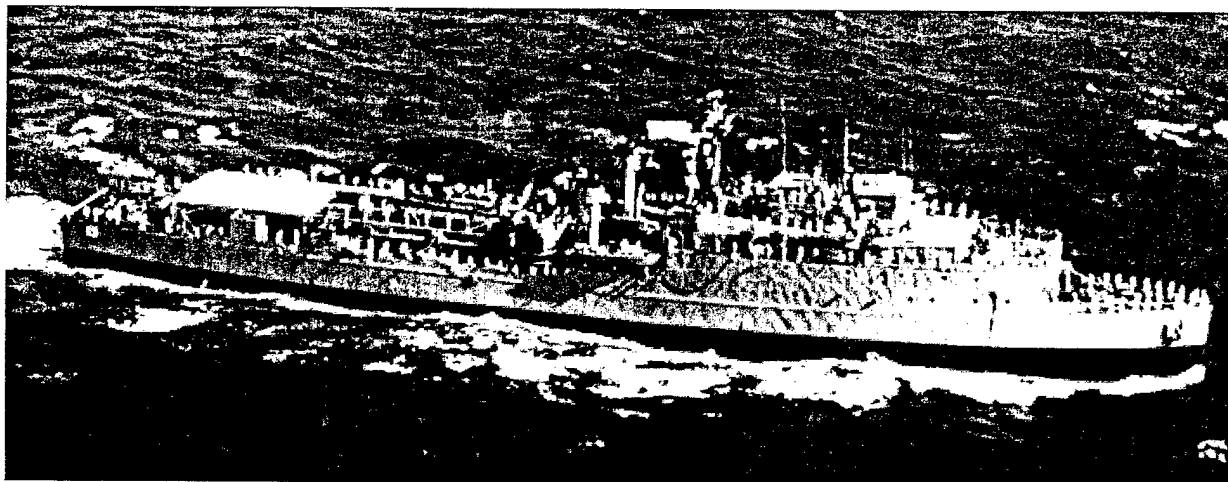*ERC, Mississippi State University, Starkville, MS*

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14. ABSTRACT

The collaborative work of Hughes Associates, Inc. (HAI), the Naval Research Laboratory (NRL), and a group at Mississippi State University resulted in developing a simulation system including Graphical User Interface (GUI) and visualization. The simulation environmment provides a runtime environment for a third-party simulation package currently FSSIM developed by HAI. This user's manual for the viewer provides documentation of the GUI layout and detailed discussion of features of the output display.

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CONTENTS

SIMULATION ENVIRONMENT FOR ONBOARD FIRE NETWORK MODEL
VERSION 1.0 – USER'S MANUAL

1.0 GUI LAYOUT

The collaborative work of Hughes Associates, Inc. (HAI), the Naval Research Laboratory and a group at Mississippi State University resulted in developing a simulation system including Graphical User Interface (GUI) and visualization. The simulation environment provides a runtime environment for a third-party simulation package currently FSSIM developed by HAI. This users manual for the viewer provides documentation of the GUI layout and detailed discussion of features of the output display.
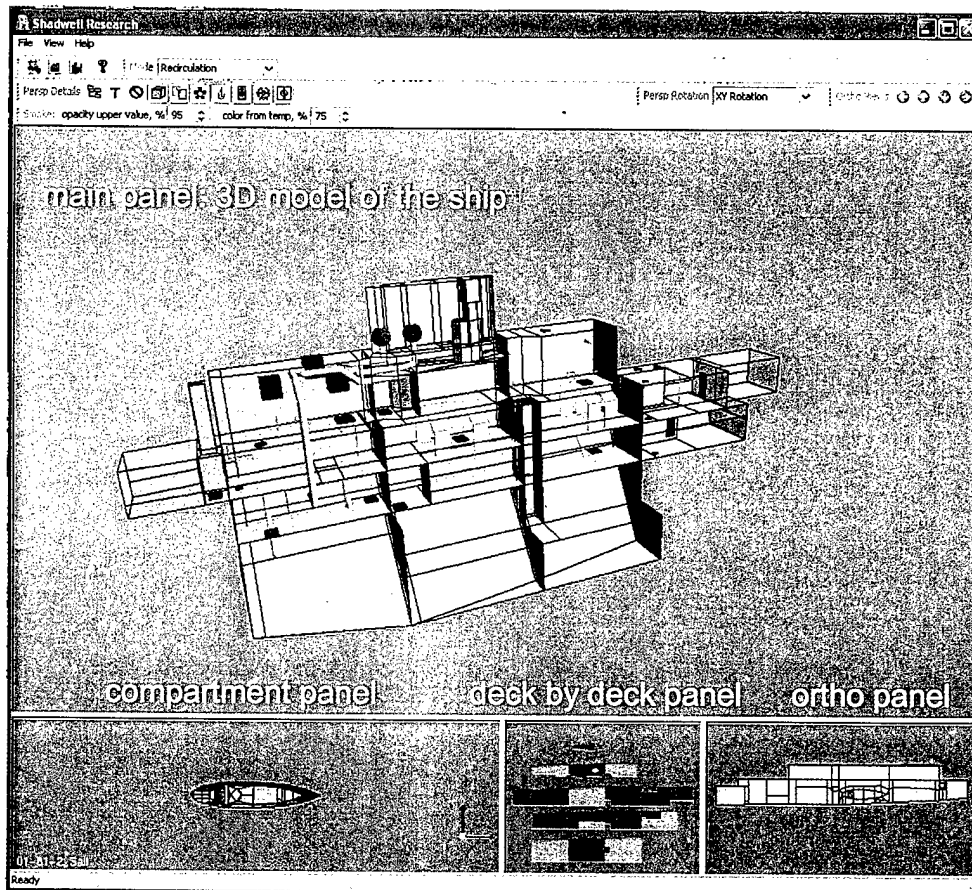

The GUI consists of seven major components: menus, toolbars, status bar, main panel displaying the 3D model of the ship, and three small panels displaying a single selected compartment, the entire ship deck by deck and orthogonal views of the ship.

2.0   RESIZING THE PANELS

By default the main panel is larger than the other ones. It can be changed by dragging the borders to the desired locations (see the figure below). When the size of a panel increases or decreases, its contents are zoomed out or in, respectively. Note that zooming preserves the aspect ratio. Therefore, if the panel is increased along x-axis, its contents may be cropped in y-direction. To remedy this, increase the y-size of the panel as well.

place the cursor on the border (it will change its regular arrow-like shape to ⇕)
press the left mouse button and drag the border to the desired location

3.0   MENUS

File

View

Help

Options ...
Exit

√ Toolbar
√ Status Bar
1
√2

About ...
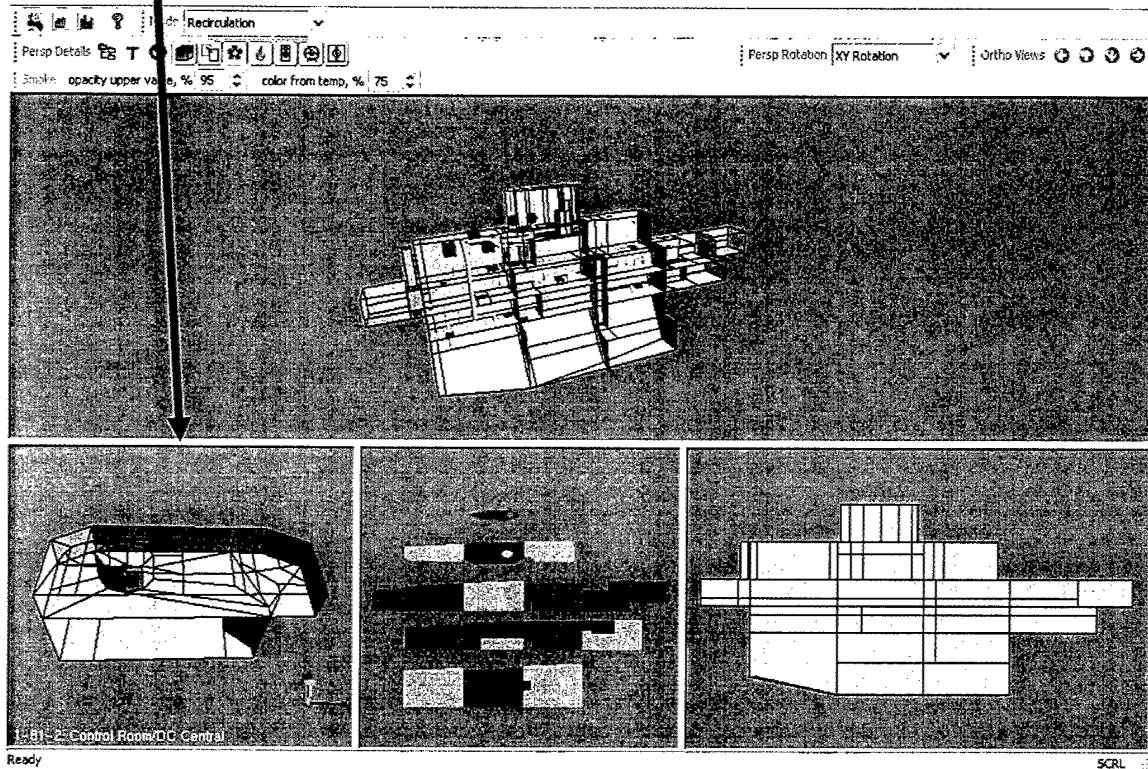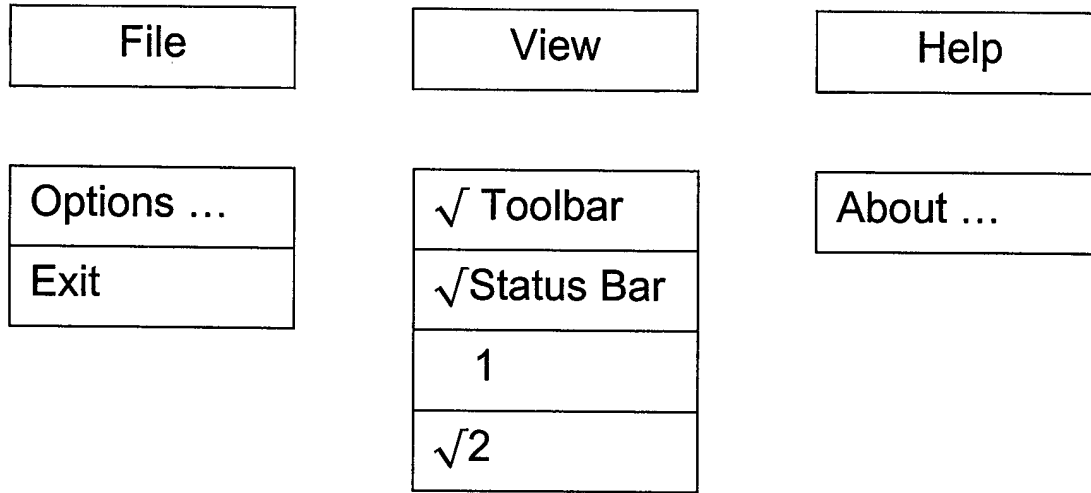
There are three menus: File, View, and Help.

3.1   File Menu

Options submenu is described in Section 4.
Exit exits the application.

3.2   View Menu

Toolbar and *Status Bar* options: allow to hide toolbars and/or Status Bar (click on the option to toggle).

1 and *2* options: essentially a debug tool. The GUI is implemented as two frames: one described in section 1 above (the main GUI window, option 2), and the frame for back-to-back comparison of two simulations (option 1). During the normal operation of the GUI, those frames are selected automatically. By clicking option 1 or 2, you can force changing the frame. Note that by doing that you may set the frame out of context. It is not recommended to use these options.
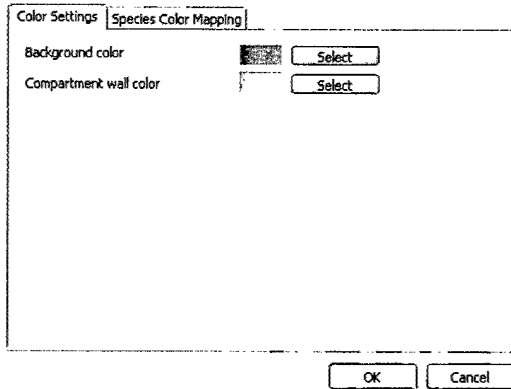
3.3   Help Menu

Option *About*: displays the credentials. Note that versions 1.0, 1.1 and 1.2 of the GUI display incorrectly the version as 0.9a. It is a bug that will be corrected in the upcoming releases.

4.0   FILE/OPTIONS MENU

Option submenu pops up a new tabbed frame that allows to set the color scheme for the GUI and color mappings for visualizations.

4.1   Color Settings

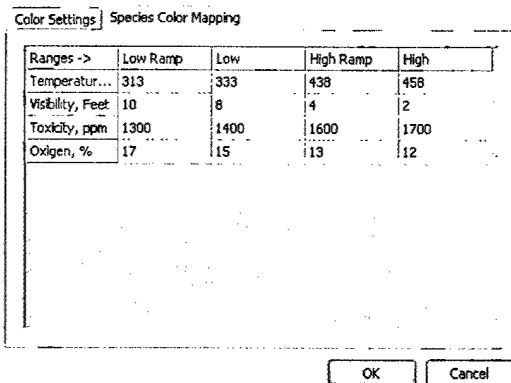| Color Settings	Species Color Mapping
Background color	[■■■] (Select)
Compartment wall color	[ ] (Select)

(OK) (Cancel)

The intention is to provide the user to modify the color of the GUI background and the color of bulkheads.

This feature is not yet implemented. By clicking the select button one can select the alternative color, but clicking on the OK button has no effect.

This feature is planned to be implemented in version 1.3

4.2   A Color Mapping

| Color Settings	Species Color Mapping			
Ranges ->	Low Ramp	Low	High Ramp	High
Temperatur...	313	333	438	458
Visibility, Feet	10	8	4	2
Toxicity, ppm	1300	1400	1600	1700
Oxigen, %	17	15	13	12

(OK) (Cancel)

This tab (which should be named just "Color Mapping") allows modifying the threshold values for color mapping of temperature, toxicity (CO concentration) and oxygen concentration, as well as opacity for smoke visualizations.

The color map is defined by four parameters (threshold values): low ramp, low, high ramp and high. The values below the low ramp threshold are ignored, that is, no visual effects are produced, as the conditions do not impact activities of humans. The values between the low ramp and the low thresholds correspond to the transition between a safe region and a region where humans need protective equipment. This is visualized by painting the compartment walls in yellow, with intensity proportional to temperature or concentration of species. The region between the low and high ramp threshold is shown in saturated yellow (i.e., constant intensity). That is, in this region the color does not show any differences in temperatures or concentration of species, as long as the values are in the range where human with protective equipment are safe. The values above the high threshold are shown in saturated red and they correspond to uninhabitable areas. Finally, the values between the high ramp and high threshold indicate the transition

between the limited access and no access regions, and are visualized by a change in hue from yellow to red, proportionally to the value.

The loss of visibility due to smoke is visualized by opacity rather than color (for details see below); nevertheless, the same four threshold approach is taken: no visibility (< 2 feet), limited visibility (between 8 and 4 feet), clear (> 10 feet) and two transitional regions. For detailed discussion of the color mappings please see the GUI documentation.
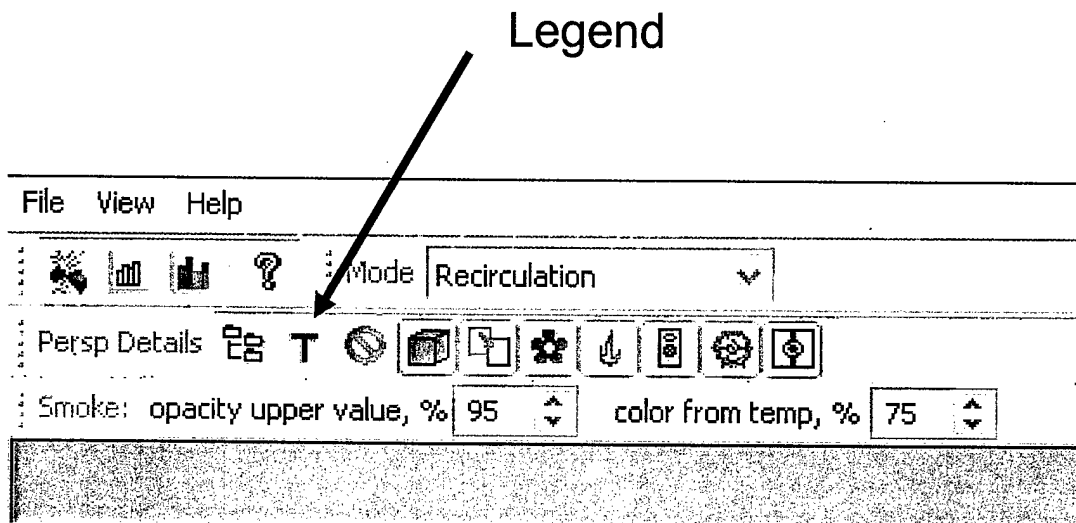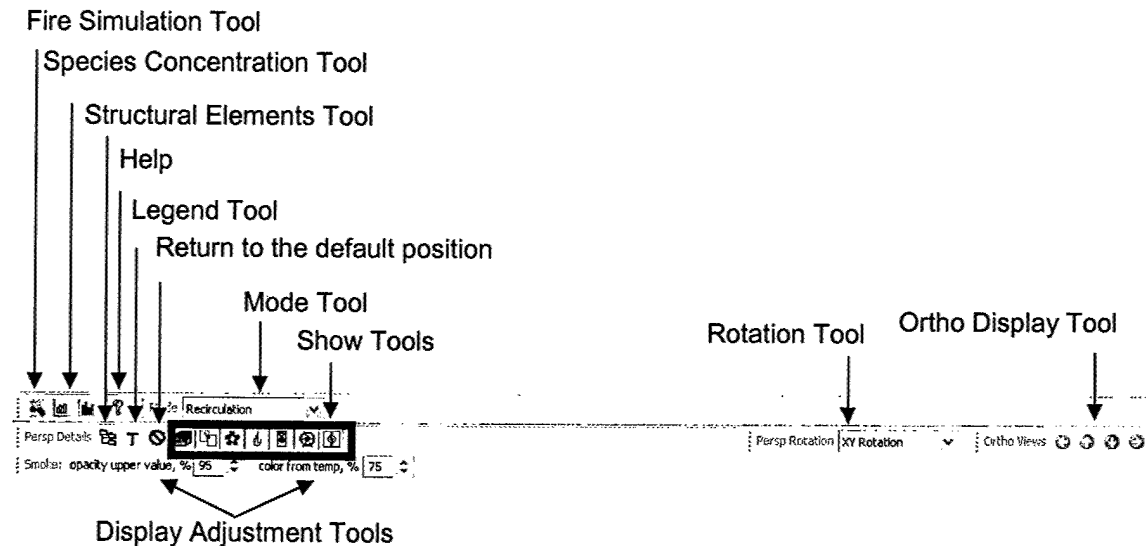
Legend

Note that the current color map can be visually displayed as a legend using the Legend tool (see Section 11)


Display Adjustments
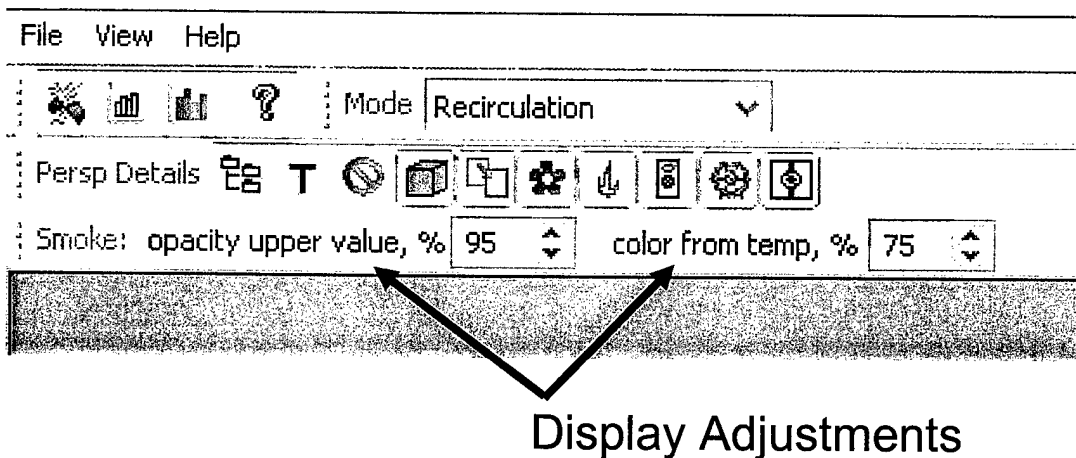
Note that visual effects of smoke and temperature (rendering details) can be adjusted using the Display Adjustment tool (see Section 12).

5.0 TOOLBAR

Fire Simulation Tool

Species Concentration Tool

Structural Elements Tool

Help

Legend Tool

Return to the default position

Mode Tool

Show Tools

Rotation Tool   Ortho Display Tool

Display Adjustment Tools

- Fire Simulation Tool: run simulation, replay or compare simulations (Section 10).
- Species Concentration Tool (not yet implemented)
- Structural Elements Tool: examine structural elements of the ship (Section 9)
- Help: the same as Help menu (Section 3)
- Legend Tool: show legend (Section 11)
- Mode Tool: select initial setting of the active elements (Section 10.1)
- Show Tools: display subsystems of the ship (Section 8)
- Rotation Tool: select rotation mode of the 3D ship model (Section 7.1)
- Ortho Display Tool: select orthogonal view of the ship (Section 6.0)
- Display Adjustment Tools: adjust visualizations of smoke and fire (Section 12)

6.0   COMPARTMENT, DECK BY DECK AND ORTHO PANELS

| Compartment Panel | Deck by Deck Panel | Ortho Panel |
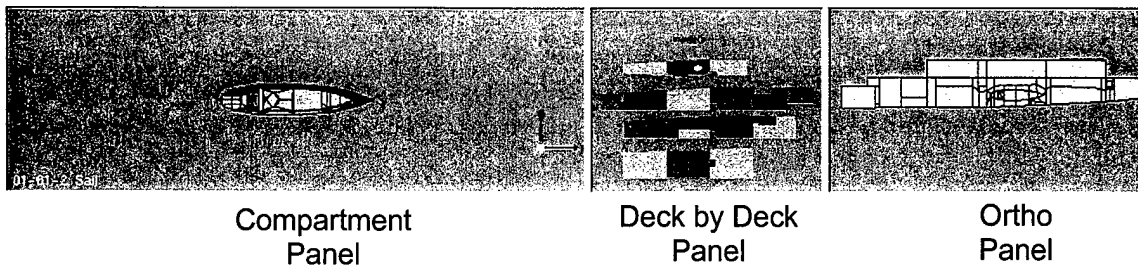
The three small panels at the lower part of the GUI provide additional view of the ship supplementing the 3D model display in the main panel. Admittedly, the current functionality of these panels is very limited, and we plan to enhance it in the forthcoming releases.

Compartment Panel
The compartment panel allows seeing one compartment at a time. The compartment to be displayed is selected in the deck-by-deck panel. In the bottom left corner of the GUI the name of the selected compartment is displayed. One can rotate the display by moving the mouse while pressing the mouse left button. The current orientation of the compartment (after rotation) is displayed in the right bottom corner. You can zoom in and out by moving the mouse up and down while pressing its middle button. Finally you can move the object by moving the mouse while pressing the right button.
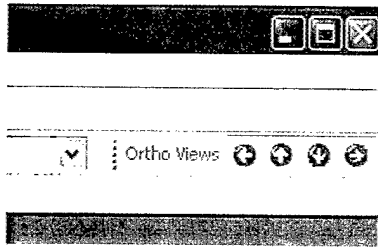
click here
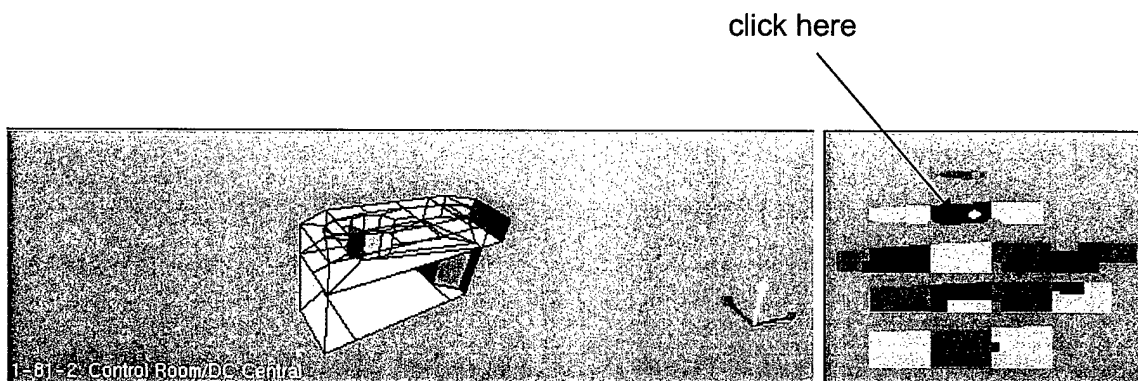
Move the mouse while pressing the left button to rotate

Deck-by-Deck Panel
This panel displays the compartment deck by deck. It can be used for selecting the compartment to be displayed in the Compartment Panel: just click on the selected compartment.
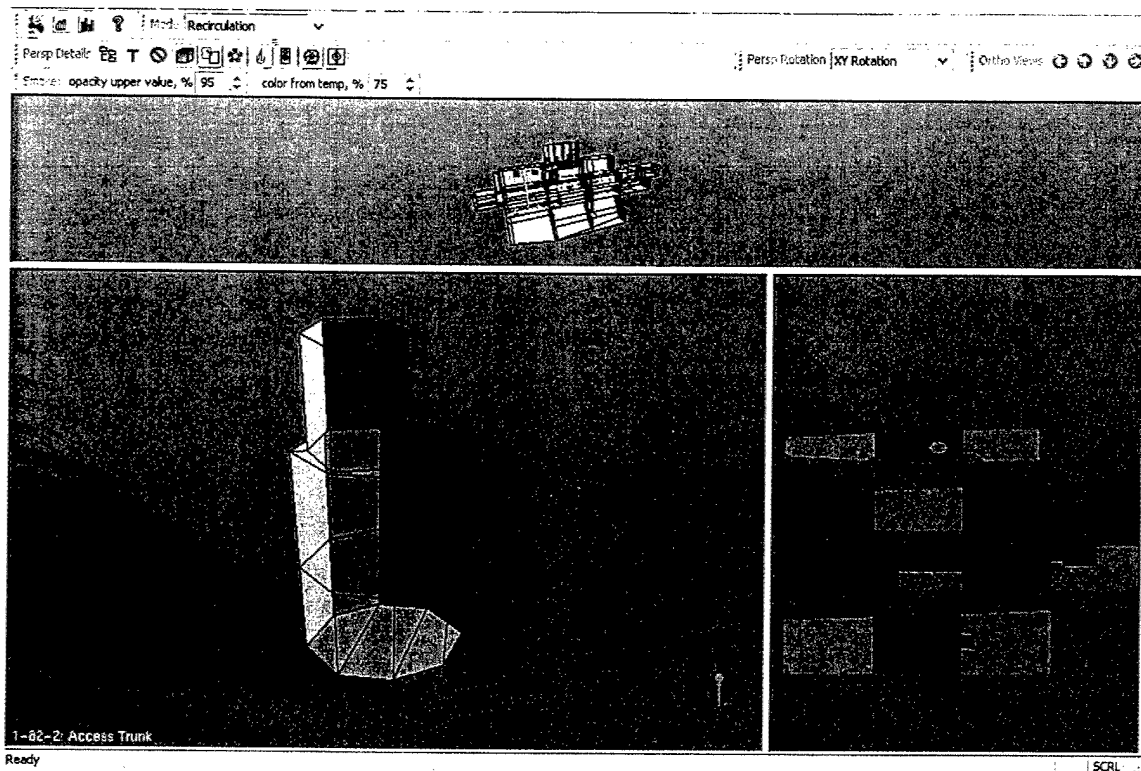
7

Ortho Panel

This panel displays orthogonal (i.e., without a perspective) views of the ship. Using the Ortho Display Tool, located in the top right corner of the GUI, the user can select top, bottom, left and right views of the ship.

The figure below show a side view of the ship in the Ortho Panel
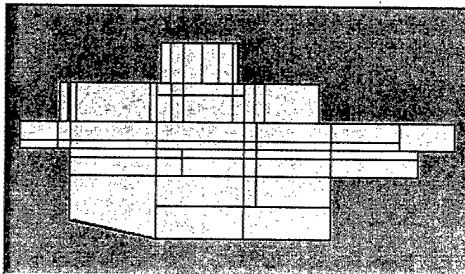
Note you can increase the panel size by dragging its borders (see Section 2).

7.0   MAIN PANEL

The main panel displays the 3D model of the ship. It is where the results of the fire and smoke simulation are visualized. In addition, state of the ship, i.e., doors, hatches, scuttles and other ventilation system elements, is set.
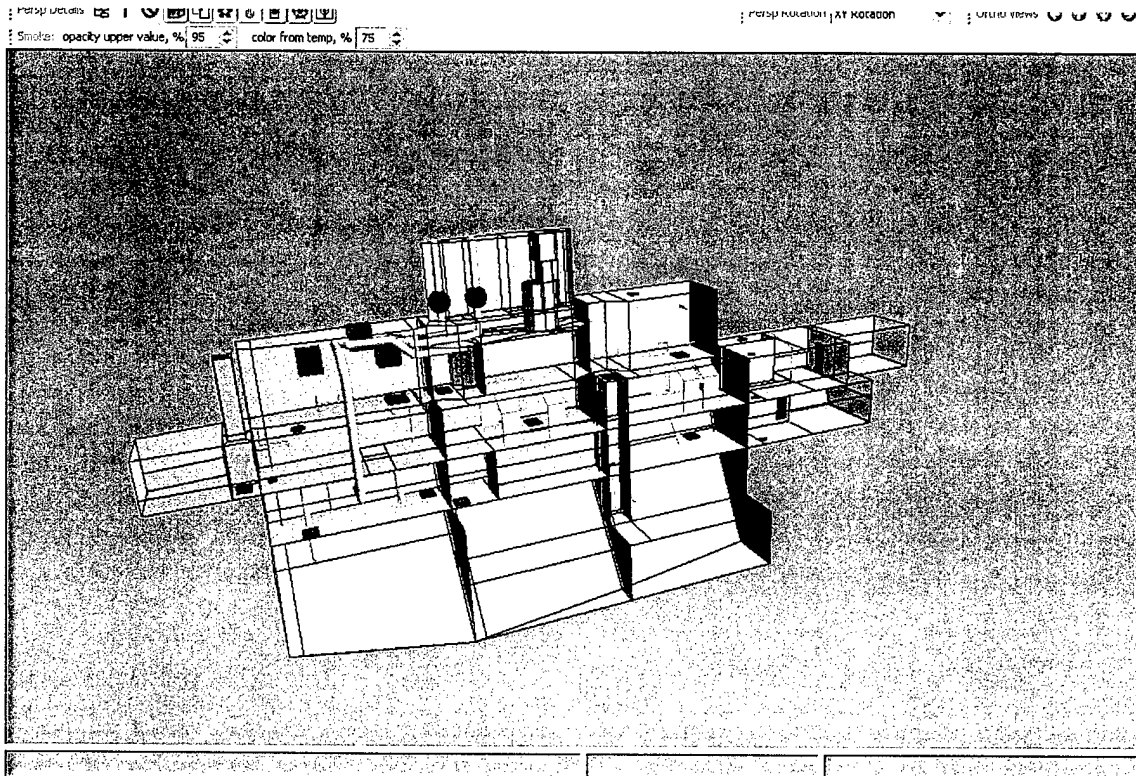

The 3D model can be rotated, zoomed in and out and moved inside the panel. The view can be further customized by selecting particular fragments of the ship and particular ship subsystem, e.g. ventilation and firemain.

Note that the front bulkheads that obstruct view into the inside of the ship are removed. When the ship model is rotated 180 degrees, the front bulkheads become back ones, and vice versa. Therefore, the removal of the bulkheads is done on-the-fly, depending on the position of the ship. The external bulkheads can be restored using the Structural Elements tool (See Section 8).

7.1 Rotating the 3D model

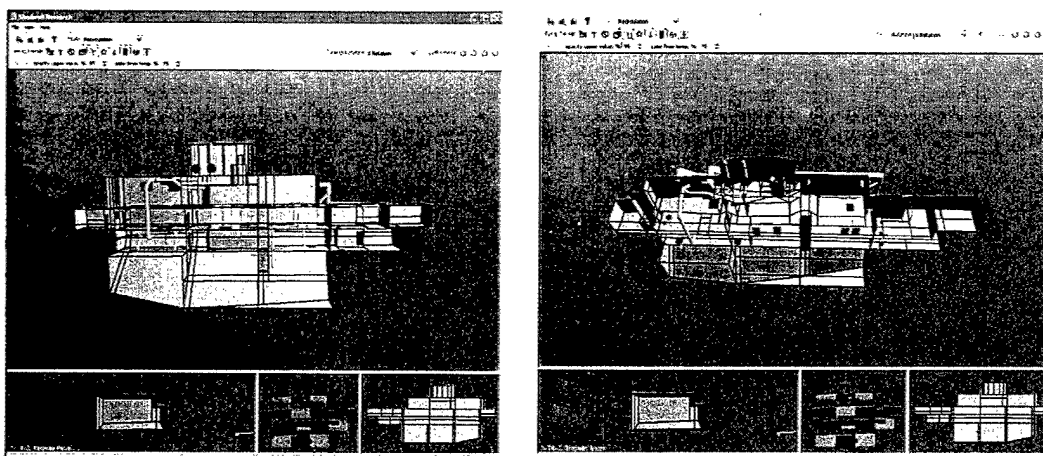The 3D model can be rotated by moving the mouse while keeping the left mouse button pressed.

There are four modes of rotating that are controlled by the rotation tool.

Rotation Tool
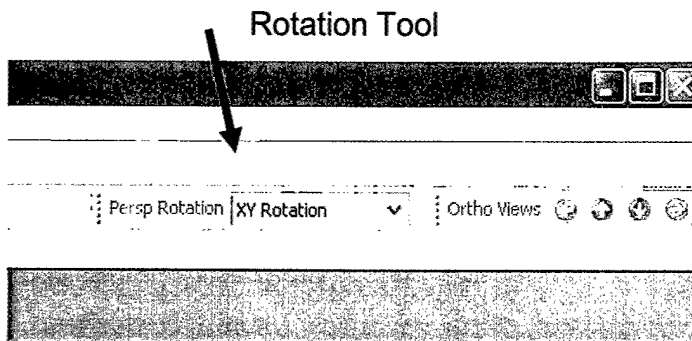
The modes are:

1. X Rotation
2. Y Rotation
3. First Occurred
4. XY Rotation (default)

7.1.1 X Rotation

In this mode the ship model can be rotated only around x-axis (horizontal one) by moving the mouse up and down. Sidewise movements of the mouse are ignored. To make the above example clearer, the model has been first rotated from its default position to that shown in the figure on the left: the side (perspective) view. Figure on the right shows the model rotated around x-axis.

7.1.2 Y Rotation
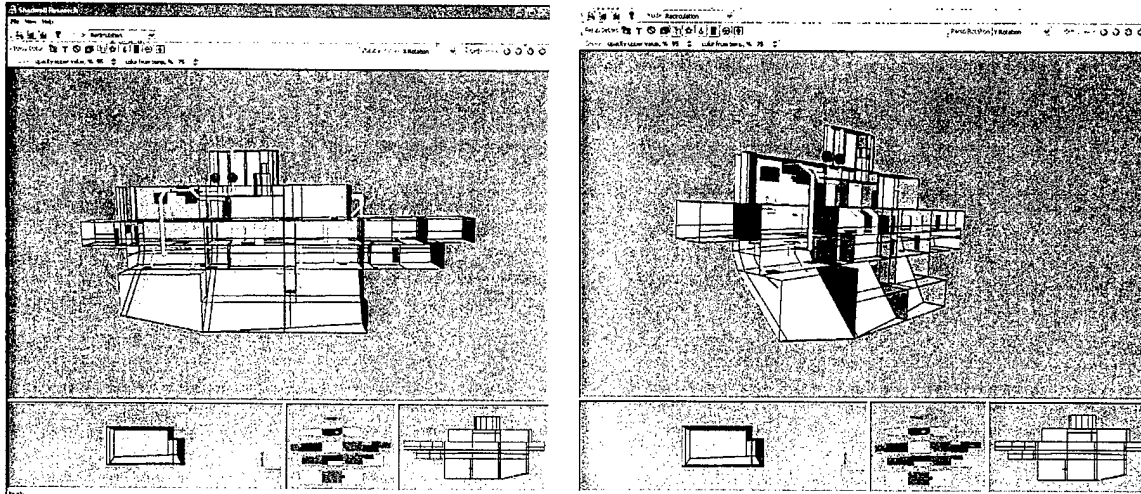
In this mode the ship model can be rotated only around y-axis (vertical one) by moving the mouse left and down. Up and down movements of the mouse are ignored. To make the above example clearer, the model has been first rotated from its default position to that shown in the figure on the left: the side (perspective) view. Figure on the right shows the model rotated around y-axis.

7.1.3 First Occurred

In this mode, the GUI picks the first mouse movement, after pressing the left mouse button. If it is up or down, it automatically switches to the X Rotation mode. If it is left or right, it switches to Y Rotation. Releasing the mouse button returns the GUI rotation mode to the First Occurred.
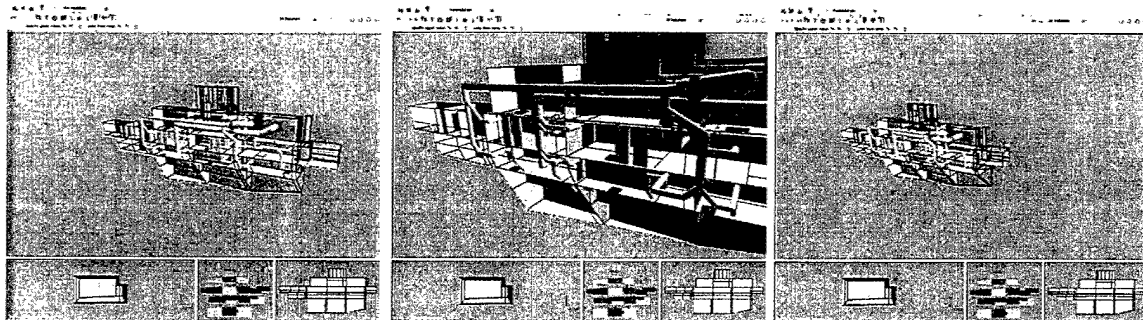
7.1.4 XY Rotation

In this mode, the ship model is rotated around the center of the model.

11

7.2   Returning to the default position
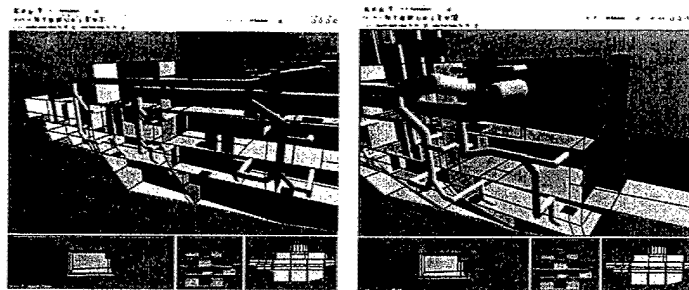
Return to the default position
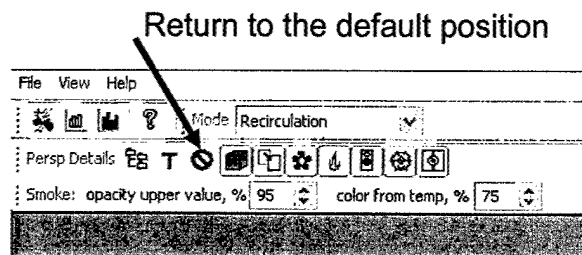
7.3   Zoom In and Out

The 3D model can be zoomed in and out by moving the mouse up and down, respectively, while keeping the middle mouse button pressed.
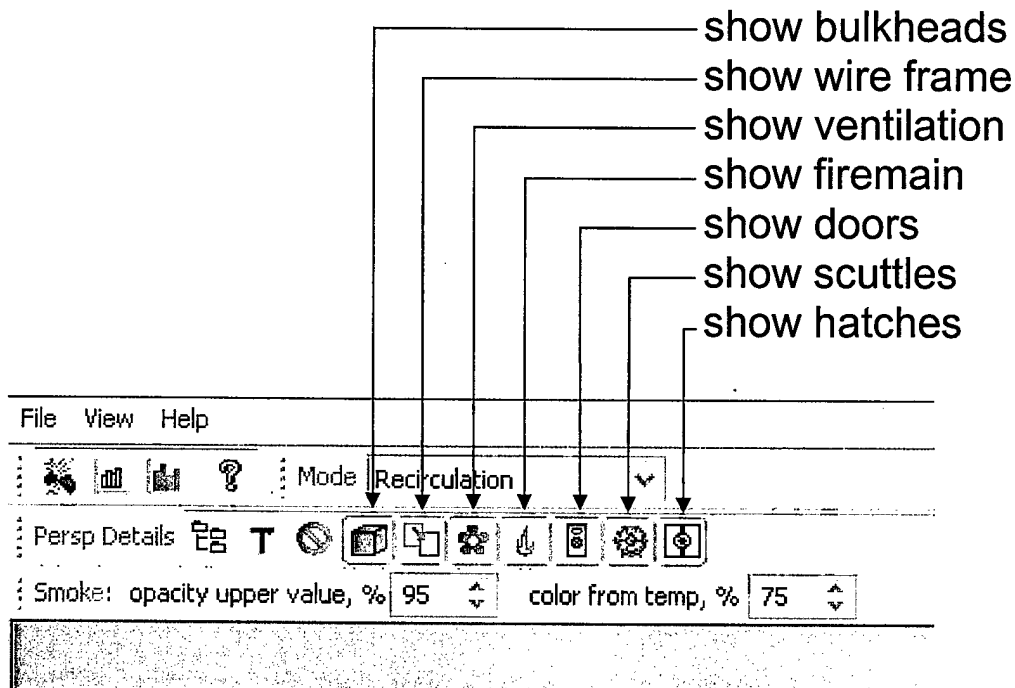

7.4   Move

The 3D model can moved inside the panel by moving the mouse, while keeping the right mouse button pressed.


12

8.0   SHOW TOOLS

Using Show Tools one can select one or more ship subsystems to be shown. By default, all subsystems are shown, that is, all Show Tools are turned on.

show bulkheads
show wire frame
show ventilation
show firemain
show doors
show scuttles
show hatches

File   View   Help

Mode Recirculation

Persp Details

Smoke: opacity upper value, % 95   color from temp, % 75

Show Tools

All buttons of the Show Tool act as toggles: Consecutive clicks on the buttons switch the display of the corresponding subsystem on and off. White background of the button indicates that the display is switched on, and grey one that it is off. In the above picture all buttons of the Show Tool are switched on. In the picture below, all buttons are switched off, except for the wire frame.
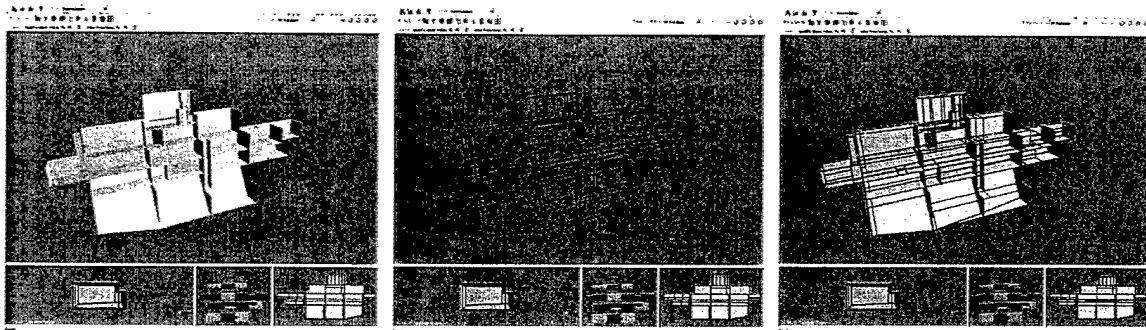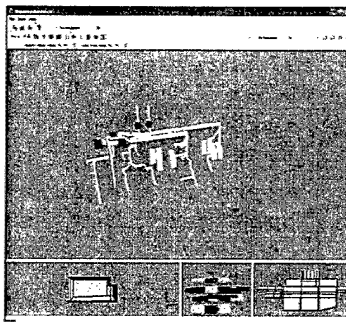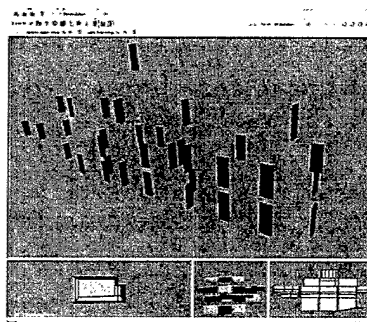
Above, the left picture shows only bulkheads, the middle one only the wire frame, and the right shows both. Below are shown the following: firemain, ventilation system, doors, scuttles, hatches, and finally ventilation, doors, scuttles and hatches together.
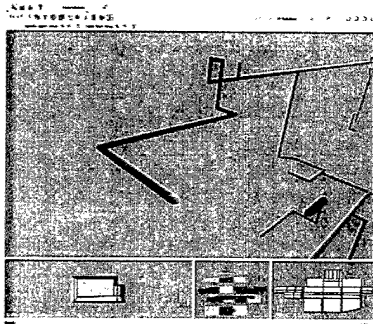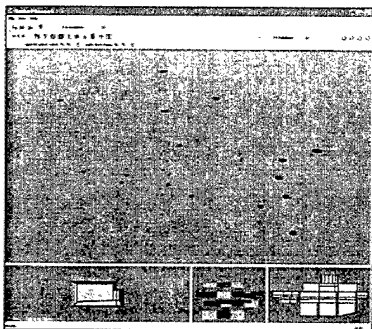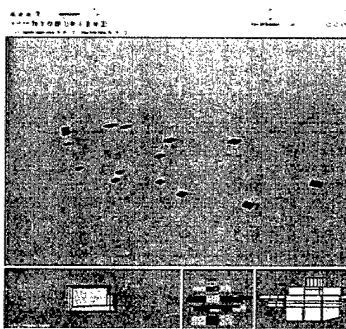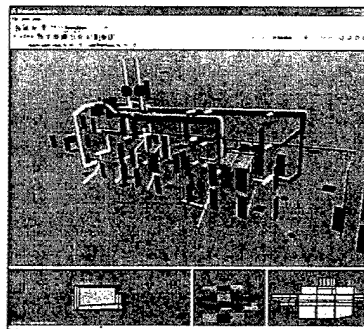

firemain (zoomed)

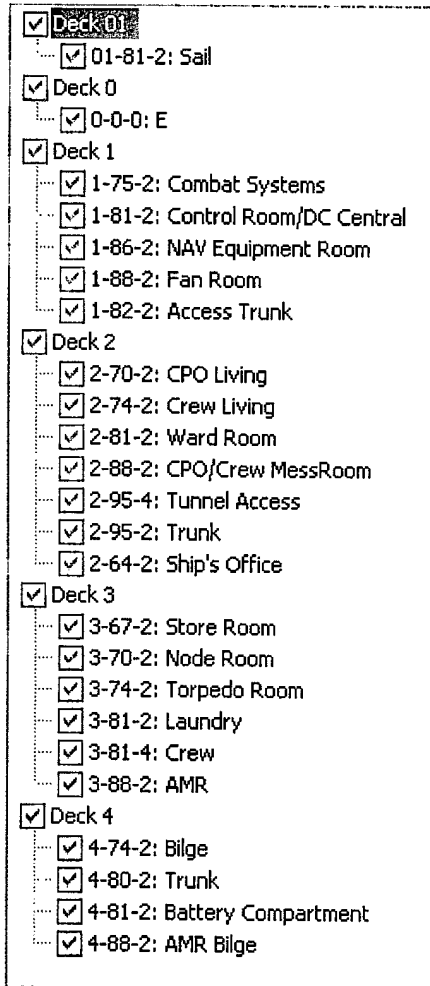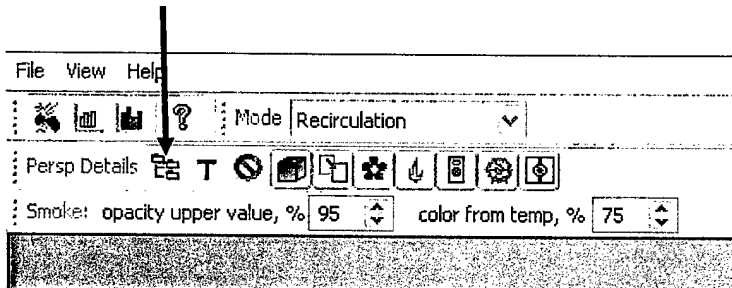ventilation system

doors

scuttles

hatches

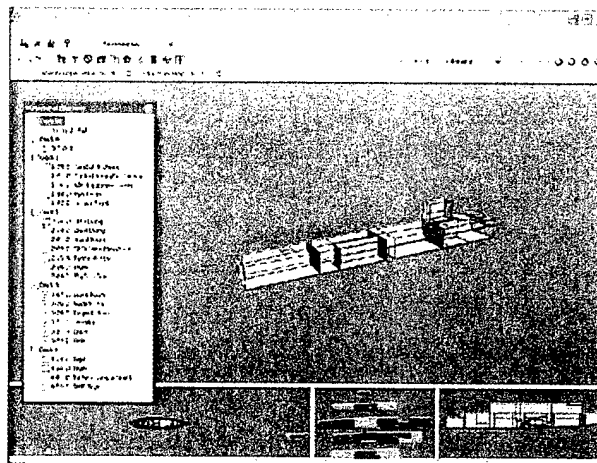ventilation. doors. scuttles and hatches
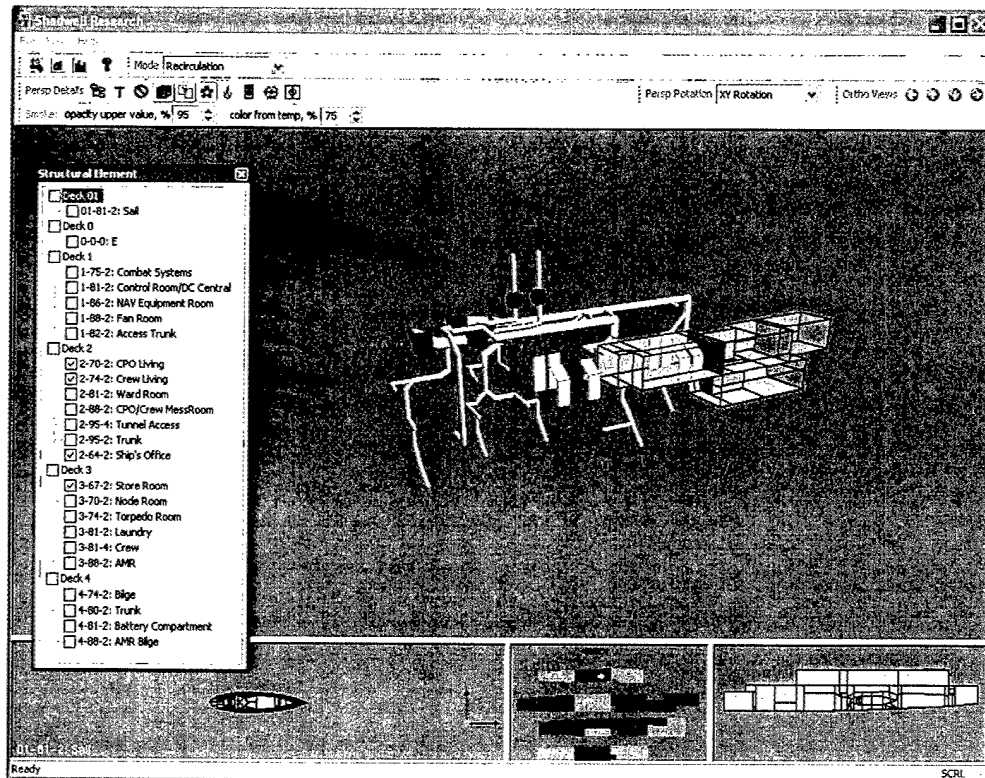
14

9.0   STRUCTURAL ELEMENTS TOOL

Structural Elements Tool

By clicking on the Structural Elements Tool a new dialog window pops up showing the list of compartments arranged by decks. Using this dialog, the user can select structural elements to be displayed or hidden. Only checked elements are displayed, and by default all elements are checked.

Any combination of compartments or entire decks can be selected or deselected. For example, in the figure below, only deck 3 is shown (with doors, hatches, scuttles, firemain and ventilation systems hidden (See section 8).

Deck 01
- ✓ 01-81-2: Sail

Deck 0
- ✓ 0-0-0: E

Deck 1
- ✓ 1-75-2: Combat Systems
- ✓ 1-81-2: Control Room/DC Central
- ✓ 1-86-2: NAV Equipment Room
- ✓ 1-88-2: Fan Room
- ✓ 1-82-2: Access Trunk

Deck 2
- ✓ 2-70-2: CPO Living
- ✓ 2-74-2: Crew Living
- ✓ 2-81-2: Ward Room
- ✓ 2-88-2: CPO/Crew MessRoom
- ✓ 2-95-4: Tunnel Access
- ✓ 2-95-2: Trunk
- ✓ 2-64-2: Ship's Office

Deck 3
- ✓ 3-67-2: Store Room
- ✓ 3-70-2: Node Room
- ✓ 3-74-2: Torpedo Room
- ✓ 3-81-2: Laundry
- ✓ 3-81-4: Crew
- ✓ 3-88-2: AMR

Deck 4
- ✓ 4-74-2: Bilge
- ✓ 4-80-2: Trunk
- ✓ 4-81-2: Battery Compartment
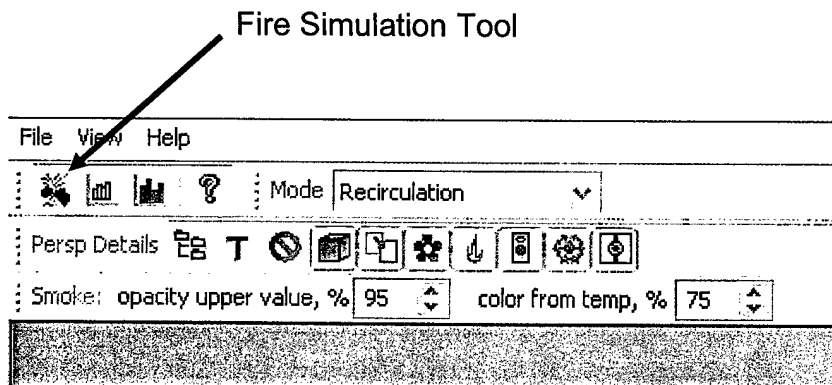- ✓ 4-88-2: AMR Bilge

In the above example, 4 compartments (3 in deck 2, and one in deck 1) are selected, and shown together with the ventilation system. By selecting only deck 0, external walls of the ship are displayed (image below).
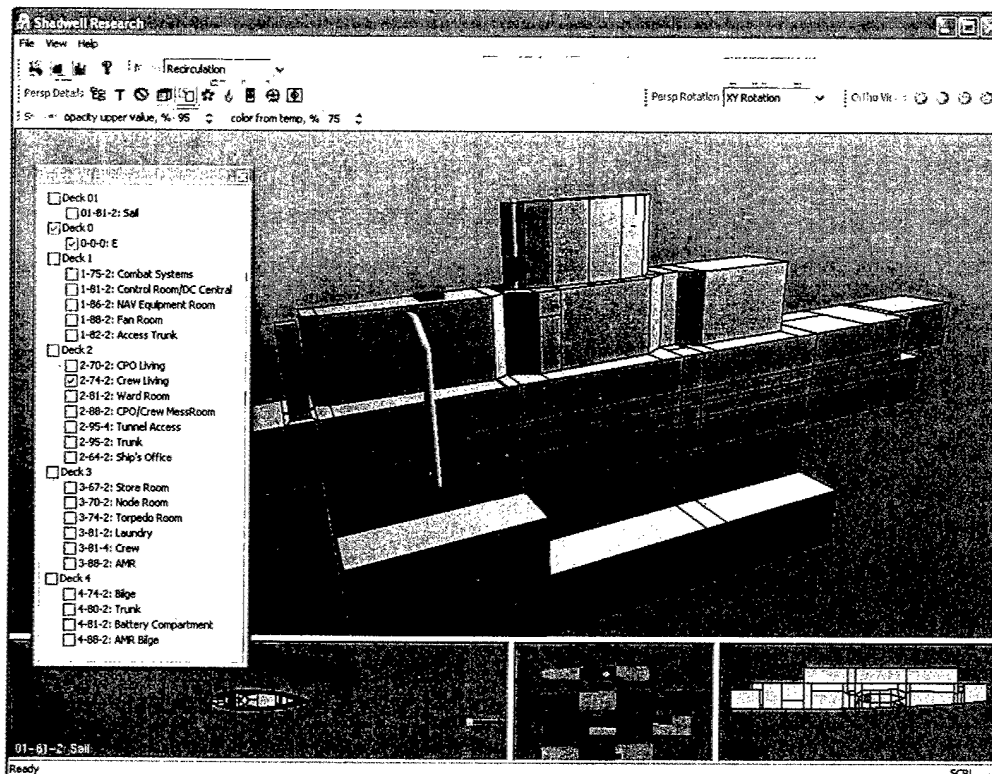
10.0 FIRE SIMULATION TOOL
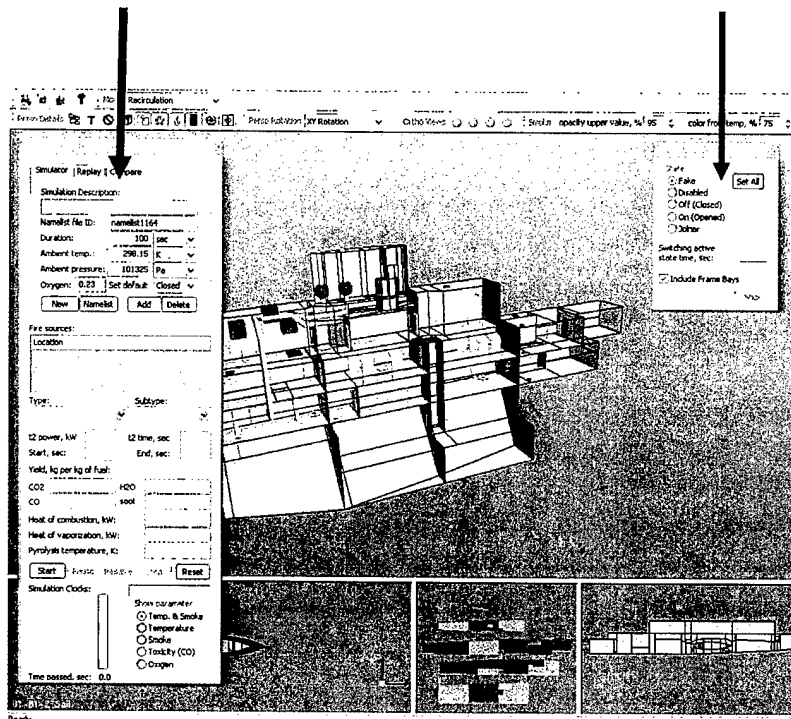
Fire Simulation Tool

Creation of a new simulation begins with the definition of states of the ship's active objects (e.g., doors and fans), setting simulation parameters (e.g., duration of the simulation and ambient environment parameters) and fire propagation parameters (e.g., number of fire sources and their strength) through the GUI.

By clicking on the Fire Simulation Tool two new dialog windows pops up: Object State Editor and Fire Simulation Dialog.

Fire Simulation Dialog   Object State Editor

One can move the pop up dialog by dragging them to desired location, by placing the cursor on the dialog box and moving the mouse while pressing the mouse left button.

Note: The Object State Editor may pop up behind the Fire Simulation dialog window, and therefore be invisible. In such situation drag the Fire Simulation dialog to the right or left.

10.1 Object State Editor

A ship is built of compartments. It also includes *active elements* like doors, hatches, scuttles, a ventilation system with fans and dampers and a firemain system with plugs and valves.

Each active object may be in several different states depending on its type. Any object can be declared as *fake* (not related to any physical object included in the simulation area) or *disabled* (its state cannot be changed, for example, one cannot open an external hatch while the submarine is submerged). An opening can be either in an *off* (or *closed*) state or an *on* (or *opened*) state. A door also can be in a *joiner* state (partially closed). Using the state edit dialog, the user can set the state of each active object separately, or set all active objects to the same state by selecting a sought state and clicking on the *Set All* button.
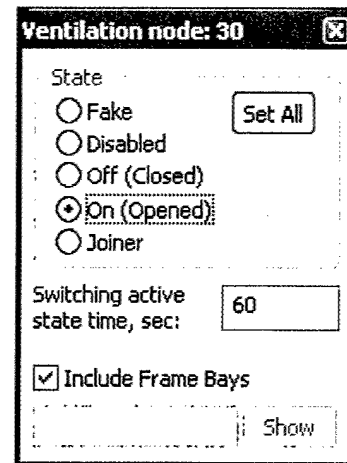
The Object State Editor

To select an active object place the cursor on the object, press and hold SHIFT key and click right mouse button. The selection is confirmed by the changed title of the Object State Editor (in the example above, ventilation node 30 has been selected).

Once the object is selected, select the state by clicking on one of the options. The change of state is visualized by a change of object color. In general a light color corresponds to on/open state and a dark color off/closed state. For example, an open door is white, a closed door is black (and a joiner is white with a big gray dot in the middle). Open damper is yellow and closed damper is brown, and so forth.

Alternatively, if any object is selected, choosing on/opened or off/closed and clicking "set all" button will set all object to that state (except those that have been declared as fake).

The network model does not accept the status changes of active object at runtime (this feature will be implemented at a later time). However, a delayed change of status can be declared prior to the model execution. For example, in the above example, the ventilation node 30 (fan) is scheduled to change its status from on to off after 60 second of the simulation time. The change of state always means a transition from one state to the opposite, e.g., from open to closed, or from off to on.

Controlling the active objects requires some experience. The current situation complicates the fact that the setting of the active elements has been optimized to quickly reproduce the setting during the actual fire tests onboard of ex-USS Shadwell. Since some objects were never used during the test, they are set by default as fake and made invisible. The forthcoming releases of this GUI will provide a more efficient support for setting the active elements.

18

The final feature available from the Object State Edit Dialog is the ability to include or exclude the Frame Bays in the simulation. Frame Bays are a test area 688 specific ventilation system feature. Frame Bays were added to the 688 test area of the ex-USS Shadwell to simulate openings between the decks and hull of a submarine through which heat, smoke, and other combustion products can travel. Frame Bays are displayed as vertical flat ventilation sections. For example, frame bays connecting the combat system room (1-75-2) and the torpedo room (3-74-2) are shown in the figure to the right.


Frame Bays
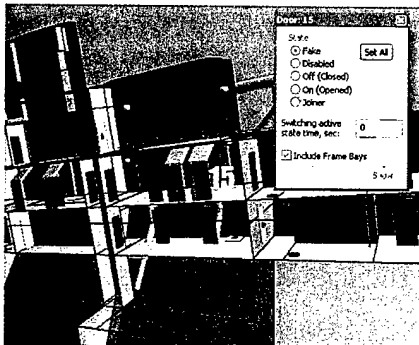
Fake doors

An example of a "fake" object is a side door on deck 2: it physically exists in the 688 test area; it is present in the CAD drawings and is therefore transferred to the database. This door is always closed during tests in the 688 area, because the 688 test area is intended to simulate a submarine, and no submarine has side doors. By introducing "fake" objects we preserve the accuracy of the ship representation (w.r.t. CAD drawings), while hiding them from the simulation operator (c.f. figure to the left).

A ship model can have hundreds of active elements. It is impractical to oblige a user to set all of them for each new simulation. To overcome this problem, several default modes are provided, each of which will define a unique set of states for all active elements. For the currently used ship model, there are three predefined modes: *Recirculation, Snorkel* and *Pier-side*. By default, the system is set to the recirculation mode.
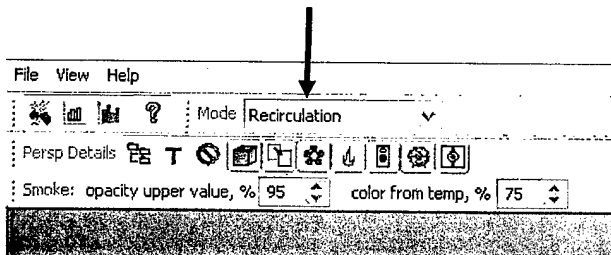
The status of the active object is passed to the model as elements of the namelist file.

19

10.2 Fire Simulation Dialog

Simulation parameters include simulation description and name of the namelist file created for the particular run, the requested duration of the simulation, external conditions (ambient temperature and pressure), and initial concentration of oxygen (assumed to be constant throughout the entire ship).

The description and name of the namelist file is used for identification of the simulation, if used for subsequent replay or comparison.

The "New" button resets the current settings to their default values. The "Namelist" button shows the actual contents of the generated namelist file; this feature is targeted only for expert users and for debugging purposes.

Each of these data fields (upper part of the GUI shown in the figure on the right) has a default value, including a description, which will be set into a name of the input namelist file in case no description is given.

The controls in the central part of the GUI allow definition of fire source(s). Each fire source has a unique set of parameters that includes location (to be selected from a drop list), fire type (constant, t^2 fire and tabular), power, starting and ending times, fuel parameters and others. By default, a fire source is constant in time with a power of 100 kWatts.

A simulation can have several fire sources, each of which may have different settings. A new fire source is created by clicking the "Add" button (and can be removed by using "Delete" button).

The Fire Simulation dialog

10.3 Running a simulation (Simulator tab)

All of this information (together with the ship geometry stored in the database, and state of the active objects) is used to generate an input file for the network model (i.e., the namelist file). The creation of the namelist file occurs when the user clicks on the "Start" button. If it succeeds, the system starts the Network model in the separate thread and begins processing its output step by step. The user may pause or suspend this process, resume execution of a suspended simulation or stop it by clicking on the corresponding button. After clicking the "Start" button, the namelist file is created, and the status line is set to "Preparing ..." If the incorrect data are entered (no fire source defined, duration is not an integer number, etc) the status line is set to "Error..."
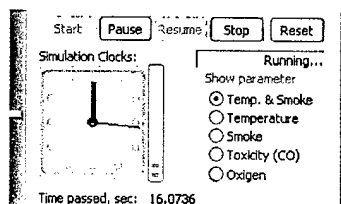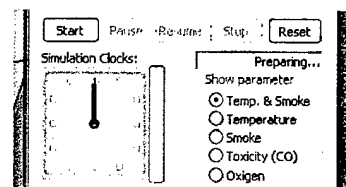
After a successful generation of the input file the simulation begins. The simulation time is shown using an analog clock, a digital clock as well as a progress bar. The digital clock provides exact time, digital clock make it easy to compare the rate of simulations with the real time, while the progress bar gives an estimate how much time is left until the end of simulation.

10.3.1 Show parameter

The results of the simulation are displayed either by changing color of the compartment walls (temperature, toxicity and oxygen concentration) or by changing opacity of the compartment (smoke). Consequently, it is not possible to see simultaneously the temperature and concentration of species. The radio buttons (to the right of the analog clock) allow selecting the parameter to be displayed: temperature and smoke, temperature, smoke, toxicity or oxygen.
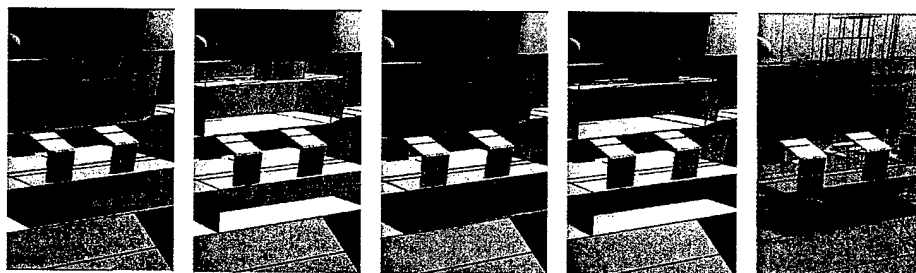
From left to right: temperature and smoke, temperature only, smoke only, CO concentration (below the first threshold thus no visual effects), and smoke only (with bulkheads hidden)

10.4 Simulation Replay (Replay tab)

Since all simulations (both settings and results) are stored in a database, each simulation can be replayed at later time. Replaying means that the results are read from an existing file and not generated in real time.

The Reply tab of the Fire Simulation dialog window

To replay a simulation, the user must select from the list of available simulations (click on select button, and Available Simulations Dialog will pop up), which contains the names of the namelist files and the descriptions of the simulations. After a simulation is chosen, the selected namelist file is parsed, and the system sets the ship's objects into the appropriate states. To start replaying press the *Start* button. The functionality of the rest of the buttons is the same as described previously.

Available Simulations Dialog: select a simulation (by clicking on the name of the namelist file or by description). The selected simulation becomes highlighted. Click on "OK" to confirm the selection, "Cancel" to close the dialog window without selecting a simulation, or "Delete" to delete the selected simulation.

The replay dialog allows the user to control how the simulation is replayed. The replay (reading from a file) is much faster than real-time simulation. To slow down the replay the user may request a pause (a delay) between time steps. On the other hand, for very long simulations, the user may also request skipping time steps (i.e., displaying every second time step or every third time step) making the replay even faster.

22

The network model uses a variable time step during the simulation. While replaying, the user may select between constant rate of time steps (which corresponds to a variable temporal rate) and constant temporal rate (with variable amount of time steps skipped).

Finally, the user may skip the beginning of the simulation and jump directly to a specified time step or specified simulation time.

10.5 Comparison of Two Simulations (Compare tab)

Back-to-back comparison of two simulations is an extension of the replay mode with two data sources and two ship models. Using the "Compare" tab of the Fire Simulation dialog window the user selects two previously run simulations and controls them the same way as it is in the case of a simple replay.   The simulations are replayed in separate threads.
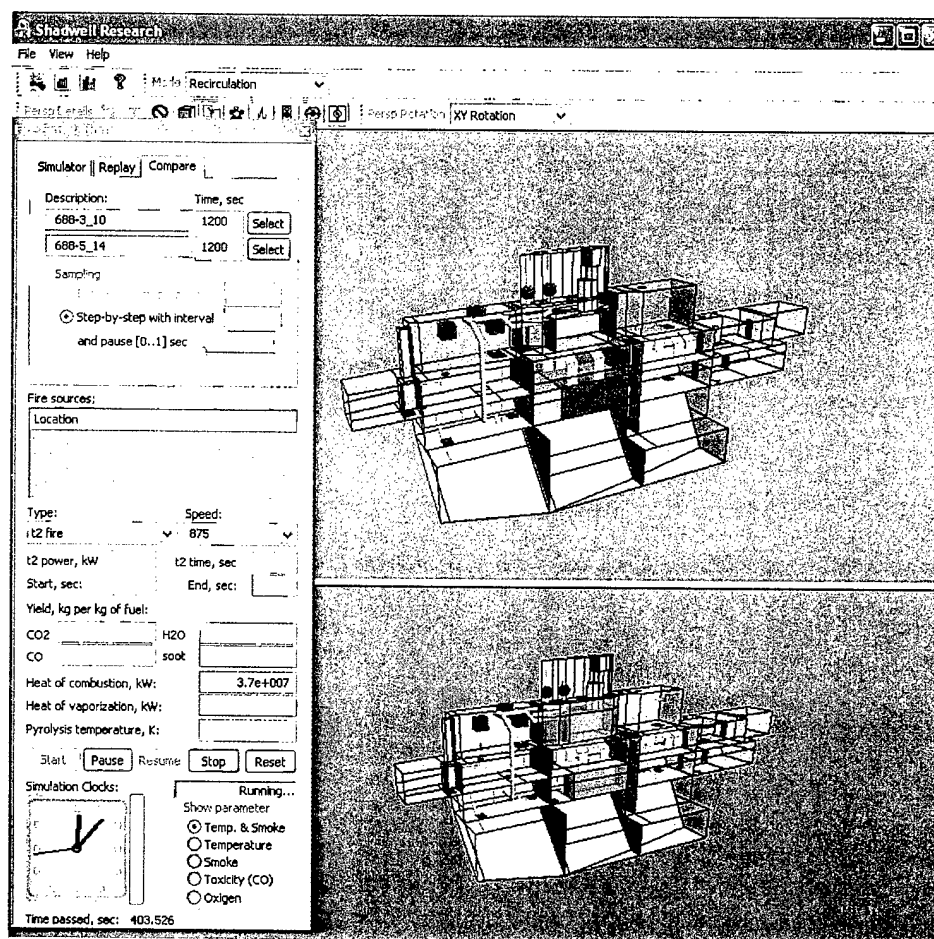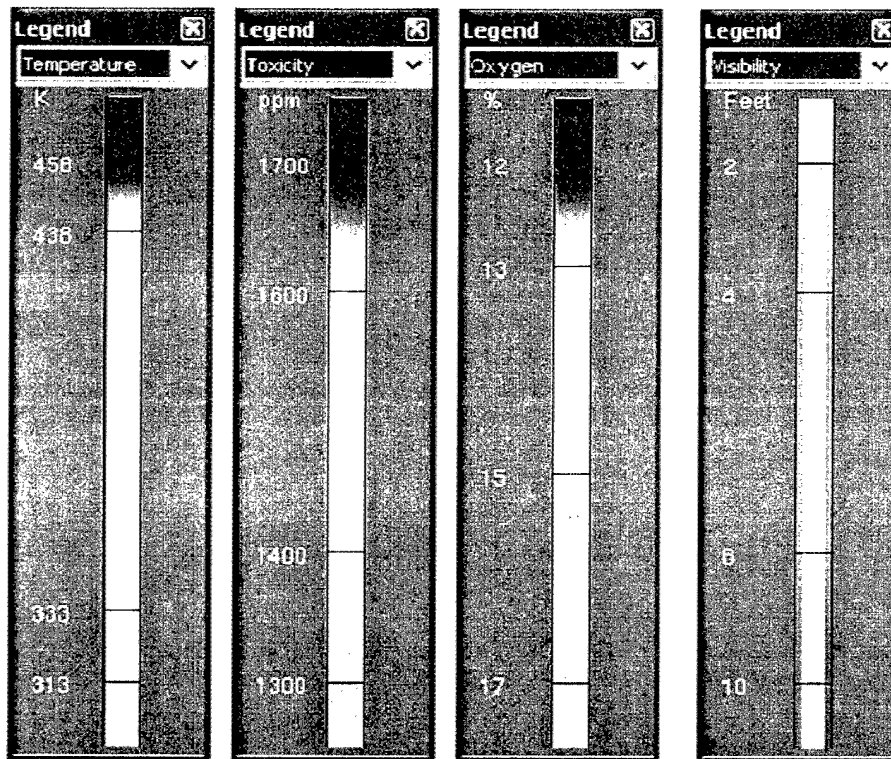

Back-to-back comparison of two previously run simulations

11.0   LEGEND TOOL
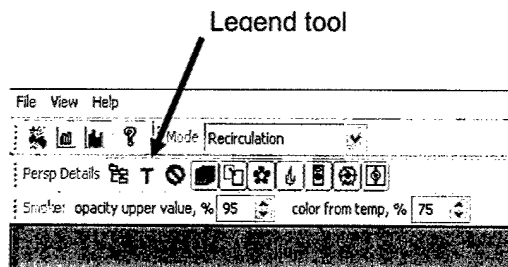
Legend tool

The Legend tool displays the legend: color mapping of temperature, toxicity and oxygen or opacity mapping.

Only one parameter is shown at a time. To select the parameter, click on the parameter name and choose from the drop down list.

12.0   DISPLAY ADJUSTMENT TOOLS

Displaying simultaneously color (temperature) and opacity (smoke) is challenging. If one allows no visibility (i.e., visibility below a threshold) be represented as a totally opaque compartment, then the temperature will be represented by a fully saturated (i.e., bright) color. This is counterintuitive, as a compartment full of smoke is expected to be dark. On the other hand, if we allow the compartment full of smoke to be very dark, then the information about the temperature is lost, because the compartment is dark and thus color is not visible. A compromise must be found.

Before color (or opacity) mapping, the parameters to be displayed are normalized (using the threshold values described in section 4.2). That is, the high value is normalized to 1.0 (or 100%). Then, somewhat arbitrarily, the high value of temperature is mapped to 75% of color saturation, and the high value of visibility is mapped to 95% of opacity. These experimentally selected values result in a realistic representation of smoke while providing perceptible information about the temperature.

Using the Display adjustment tools, this mapping can be adjusted to the user liking
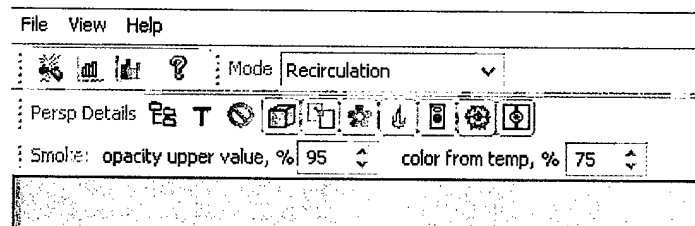
For further support please contact Tomasz Haupt, haupt@erc.msstate.edu